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ABSTRACT

B. S. Bloom's theory of school learning states that three independent variables account for most of the variation in students' achievement: cognitive entry behaviors (CEB), affective entry characteristics, and the quality of instruction. These variables determine the nature of learning outcomes--level and type of achievement, rate of learning, and affective characteristics. Bloom developed his mastery learning strategy to produce successful learning through modifications to student entry characteristics and instructional behaviors. A study examined the interactive effect of CEB with mastery versus non-mastery learning strategies of instruction on reading comprehension. Subjects, 180 third grade students, were randomly assigned to four treatment groups--two mastery learning groups (90% and 70%) and two control groups (non-mastery and control). They were individually instructed in a sequence of three learning tasks that were designed to teach word recognition, word meaning, and word order. Several assessment instruments were used to measure the children's CEB and learning outcomes. Results showed a significant overall CEB and treatment interaction on immediate achievement in comprehension. Low CEB students benefited relatively more than high CEB students from the mastery learning treatment. The findings confirmed the interactive relationship between initial abilities and instructional methods postulated by Bloom. The CEB plus treatment interaction on long-term retention was not significant, suggesting the need for extended mastery learning programs for low CEB students. (FL)

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AN APTITUDE-TREATMENT INTERACTION IN A MASTERY LEARNING MODEL OF INSTRUCTION

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ABSTRACT

This research examines the interactive effect of cognitive entry behaviours (CEB) with mastery versus non-mastery learning strategies of instruction on reading comprehension. One hundred and eighty grade three students were randomly assigned to four treatment groups: 90% mastery, 70% mastery, non-mastery and control. Subjects were individually instructed a sequence of three learning tasks that aimed to teach the reading skills of word recognition, word meaning and word order. Results of a multivariate multiple regression analysis indicated a significant CEB x treatment interaction on immediate comprehension achievement. A comparison of regression slopes revealed that low CEB mastery learning students benefited relatively more than high CEB mastery learning students. These findings confirmed the interactive relationship between initial abilities and instructional methods postulated in Bloom's theory of school learning. The CEB x treatment interaction on long-term retention was not significant, suggesting the need for extended mastery learning programmes for low CEB students.

An Aptitude-Treatment Interaction in a Mastery Learning Model of Instruction

Bloom's (1976) theory of school learning states that three independent variables account for most of the variation in student achievement. He has postulated that variation in cognitive entry behaviours (CEB), affective entry characteristics and the quality of instruction determine the nature of learning outcomes. The learning outcomes are level and type of achievement, rate of learning and affective characteristics. Bloom maintains that where student entry characteristics (or aptitude) and quality of instruction are optimal, attainments will be high and there will be little variation in subsequent achievement measures. Using the concept of mastery learning, Bloom has developed an instructional strategy that is designed to produce successful school learning through modifications to student entry characteristics and instructional procedures.

Several key features can be identified in Bloom's mastery learning strategy. Course content is typically organized into a set of sequential learning tasks and a mastery criterion is specified for each task. Formative tests are constructed and feedback and corrective procedures are developed at every stage of the learning sequence. Adequate learning time is provided to ensure that the prescribed criterion level is attained by all students on each task before advancing to the next task in the series. At the completion of the final learning task a

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summative test is administered to assess total achievement.

Bloom (1976) maintains that mastery learning enables most students to achieve at a level that only the top 10% can attain under traditional instructional approaches. Under conventional teaching procedures, high aptitude students are expected to achieve at a more advanced performance level than low aptitude students. Bloom, however, has predicted that low aptitude students will achieve at a level comparable with high aptitude students in a mastery learning programme.

Implicit in the relationships explained above is an aptitude-treatment interaction (ATI). There is a postulate of an aptitude-treatment interaction in the claim that mastery learning enables both high and low aptitude students to attain a high level of achievement which only the high aptitude students can attain under traditional instruction. In other words, Bloom is suggesting not only that the mastery learning strategy is superior to conventional approaches for all students, but also that mastery learning programmes are expected to benefit low aptitude students relatively more than high aptitude students. This special facilitative effect of the mastery learning strategy for low aptitude students can be interpreted as an aptitude-treatment interaction.

Statistically, an aptitude-treatment interaction is indicated when the slopes of the regression of achievement on aptitude under two treatments are significantly different. In a regression sense an ATI exists whenever the regression of

outcome from one type of treatment upon the students' pretreatment characteristics differs in slope from the regression of outcome from another treatment on the same entry characteristics (Cronbach & Snow, 1977).

Mathematically, the regression slope of achievement on aptitude is specified by the regression coefficient which is calculated from the standard deviations of the aptitude and achievement measures and the correlation between the two measures. A regression coefficient $\underline{B}_{YX}$ (for the regression of Y on X) is given by the formula $\underline{B}_{YX} = \underline{r}_{XY} \underline{S}_Y / \underline{S}_X$

where $\underline{r}_{XY}$ = the correlation between the two measures X and Y;

$\underline{S}_Y$ = the standard deviation of the measure Y;

and $\underline{S}_X$ = the standard deviation of the measure X.

It follows that a change in any one of these three parameters (with the other two held constant) will result in a corresponding change in the regression slope.

Bloom (1976) has presented evidence to demonstrate the reduction of variance in the achievement measure and a smaller correlation between initial CEB and final achievement for students who have completed a mastery learning programme compared with students in a non-mastery learning programme. As explained above a reduced standard deviation in the outcome measure and a smaller correlation between aptitude and achievement measures must result in a smaller regression coefficient. It follows that Bloom's postulates of the differences in the standard deviations of the outcome measure

and in the correlations of the CEB with achievement measures between a mastery learning and a non-mastery learning group can be extended to imply a difference in regression slopes between the two treatment groups. An interaction exists when the regression slope for one treatment is significantly different from the regression slope for another treatment. The implication is that when mastery learning instruction is contrasted with non-mastery learning instruction for students across all CEB levels, a significant CEB x treatment interaction is highly probable. It thus follows that in Bloom's statement of the effectiveness of the mastery learning strategy for students of different CEBs compared with a non-mastery learning strategy, he is suggesting an interaction between CEB and treatments.

The majority of the mastery learning studies reported in the literature are concerned only with the overall effectiveness of the mastery learning strategy for all students. Few mastery learning studies have attempted to systematically examine the hypothesis of an aptitude-treatment interaction deduced from Bloom's postulates of mastery learning. Of the ten available mastery learning studies which have specifically investigated the interactive relationship of aptitude with treatment, one indicated a statistically significant aptitude x treatment interaction (Tobias & Ingber, 1976). Two others (Burrows & Okey, 1975; Wyckoff, 1974) tested the aptitude-treatment interaction statistically but the

interaction marginally failed to attain significance, probably because of the power of the statistical tests employed. Another two (Detheux, Leclercq, Paquay & Thirion, 1974; Kim, 1969) did not statistically test the significance of the interaction; however, their findings could be interpreted to indicate the presence of an interaction. The remaining studies (Ward, 1979; Jones, 1976, Contreras, 1975; Fagan, 1975; Wentling, 1973) offered no clear-cut conclusions due to limitations of one sort or another. The present study attempts to extend our knowledge in this area.

A previous study (Chan & Cole, 1979) has demonstrated evidence in support of the hypothesized CEB x treatment interaction. In that investigation, the effects of mastery and non-mastery strategies of instruction on reading comprehension were compared. The instruction involved a sequence of three learning tasks : word recognition, word meaning and word order. The subjects were 120 grade three children, randomly assigned to two mastery and two control groups. Results indicated a significant CEB x treatment interaction and showed that the low CEB students benefited relatively more than the high CEB students in the mastery learning programme. However, the conclusions were tentative because of the exploratory nature of the investigation and also because of limitations due to a possible ceiling effect caused by the particular measurement scale employed. The present investigation aimed to replicate the earlier study while extending the range of difficulty

levels in the comprehension measures, which was made possible by the use of the Rasch model (Rasch, 1960, 1980) in the construction of the assessment instruments.

To summarize, the main purpose of the present study was to test the hypothesis of a CEB x treatment interaction deduced from Bloom's postulates of mastery learning. It was the aim of the investigators to examine whether mastery learning procedures were more effective for low CEB students relative to high CEB students. The second objective of the present research project was to examine whether the effects of the mastery learning programme could be retained in the long term.

METHOD

Subjects

The subjects in the present study were 180 regular grade three students randomly drawn from six state primary schools in the Perth metropolitan area in Western Australia. Children from each school were randomly assigned to four treatment groups. There were two mastery learning groups (90% and 70%) and two control groups (non-mastery and control). Each group consisted of a total of 45 students. Table 1 depicts data on chronological age, pretest scores and sex ratio for the four groups.

Insert Table 1 about here

Assessment Instruments

Several assessment instruments were employed in the present study to measure the subjects' cognitive entry behaviours and learning outcomes. The SRA Primary Mental Abilities tests (revised 1962), ACER Primary Reading Survey tests (1971), a word attack skills test and a word recognition test provided CEB measures. Learning outcomes in reading comprehension were measured by two summative achievement tests and two retention tests.

Apart from the SRA Primary Mental Abilities tests and the ACER Primary Reading Survey tests, which were standardized tests, the other assessment instruments were specially constructed for the present study, employing the Rasch model (Rasch, 1960, 1980), one alternative form of latent trait models.

Word attack skills test. The word attack skills test was constructed to assess knowledge of the essential cognitive prerequisites on which the first learning task (word recognition) depended. It consists of two subtests, each with 25 items. The item banks were calibrated on a sample of 81 grade three students. Kuder-Richardson 20 reliability coefficients of .85 and .84 were obtained for the two subtests of phonetic analysis and structural analysis, respectively.

Word recognition test. The word recognition test consisted of 60 isolated words. These 60 words were the words selected for the first learning task, a description of which is given in the

next section on instructional tasks. Pupils were required to read each word aloud. The test yielded a Kuder-Richardson 20 reliability of .97 on a sample of 36 grade three pupils. A concurrent validity coefficient of .87 was obtained when test scores were correlated with the St Lucia Graded Word Reading Test (Andrews, 1973).

Immediate comprehension posttest and long-term comprehension retention test. The immediate comprehension posttest and the long-term comprehension retention test were parallel forms. The format of the tests consisted of passages followed by multiple-choice questions. The comprehension posttest contained five short stories with a total of 28 factual and inferential questions. In the comprehension retention test there were also five short stories, giving a total of 32 factual and inferential questions.

Both tests were constructed from a commonly-calibrated item bank of 16 passages which were calibrated by means of the technique of linking tests on four separate calibration samples of 121 third-grade, 126 fourth-grade, 124 fifth-grade and another 94 fifth-grade students. All passages were based on a common core of vocabulary items and sentence structures. The item bank was so constructed in order to extend the difficulty range of the test items beyond the test-taking capacity of students from one single grade level. Yet because of their common calibration, all items in the item-bank were automatically equated on a common scale and any subset of items

can be selected from this item bank to make up a test. Each item still provides its unique logit difficulty estimate relative to the common scale.

In the calibration study, Kuder-Richardson 20 reliability coefficients of .83, .82, .81 and .78 were obtained for the four pilot samples of third, fourth and fifth graders.

Immediate cloze posttest and long-term cloze retention test. Like the comprehension tests described in the above paragraph, the immediate cloze posttest and the long-term cloze retention tests were parallel forms. Each test consisted of 30 items, all presented in a multiple-choice cloze format. Single words or phrases were deleted at random from sentences or short paragraphs and pupils were required to select from a set of four plausible alternatives the one that best completed the sentence. Both semantic and syntactic knowledge and the ability to use context clues were tested. The sentences and paragraphs in the cloze tests were similar to those used in the passages for the comprehension tests described earlier.

These two tests were selected from a commonly-calibrated pool of 65 items, which was obtained using the same procedures as those for calibrating the comprehension item bank reported in the previous section. Three standardization samples of 81 grade three, 107 grade four and 105 grade five students were involved, yielding Kuder-Richardson 20 reliability coefficients of .80, .80 and .83, respectively.

Instructional Tasks

The mastery learning programme aimed to improve competence in reading comprehension. A sequential series of three learning tasks was designed. All instructional materials involved the common core of vocabulary items and sentence structures used in the construction of the comprehension passages for the tests described earlier.

Learning task one. The first learning task was a word recognition exercise. In a pilot study, 53 grade three students were asked to read orally the passages in the two comprehension tests described previously and the 60 most often mispronounced words were selected for this first learning task. Ten sets of 10 words each were randomly selected from this pool of 60 words, one set for each additional learning trial. Each word was printed on a 10 x 15 cm white index card. These cards were presented one at a time and the subjects were asked to read the words aloud.

Learning task two. The second learning task was a vocabulary exercise. In a pilot study 46 grade three students were asked to choose synonyms for the 60 words selected for the first learning task and the 30 words on which the students made the most errors were selected for this vocabulary task. Five sets of 10 words each were compiled from this pool of 30 words. Each word was presented in context and subjects were required to select from four plausible answers the one that was the best synonym for the given word. Each sentence was typed onto a 10

x 15 cm white index card with the target word underlined. The list of the four plausible answers was typed below each sentence. At the back of the cards were illustrations to highlight the meaning of the target word. These illustrations were used in teaching the meaning of the given words. As each card was presented, subjects were required to read the sentence silently to themselves. Then the four answers were read to the subjects who were then asked to choose the correct answer. Both the ability to recognize the target word and knowledge of the word meaning were involved in the task.

Learning task three. This was a word order (sentence anagram) activity. Twenty sentences were constructed, made up of words included in the previous two tasks and using the same sentence structures as those employed in the comprehension passages. Apart from these 20 basic sentences to be used for the initial instruction, four sets of 10 sentences each were compiled for the additional learning trials. The sentences in these four sets were similar but not all identical to the 20 basic sentences. Each sentence was divided into five units. Each unit was printed on a 3 x 10 cm white card. These units were presented in random order to the subjects who were required to read the words to themselves and to arrange the units in the appropriate order to form a meaningful sentence. Competent performance on this task required word recognition skill as well as semantic and syntactic knowledge.

Procedure

The research programme was conducted by the first investigator in four distinct phases to be described below.

Phase one - assessment of CEB. Prior to the commencement of the main study, all grade three students in each of the six participating schools were pretested on three measures of CEB using the Primary Mental Abilities test, the ACER Primary Reading Survey tests and the word attack skills test. All these three tests were group-administered to the children in their classrooms in three separate sessions, following standardized procedures. The fourth CEB test, the word recognition test, was administered individually to subjects in all four treatment groups as a pretest of the first learning task at the beginning of the instructional session. Subjects were presented the 60 word cards one at a time and asked to read the word aloud.

Phase two - the instructional programme. Subjects were randomly assigned to four treatments. In the 90% mastery group, students were required to attain 90% mastery on each of the three learning tasks. Similarly, subjects in the 70% mastery group were required to attain a minimum of 70% mastery on each task. Subjects in the non-mastery group were provided only with the initial instruction on each of the three learning tasks, regardless of what mastery level they achieved in that initial instruction. The control group did not receive instruction on any of the three learning tasks. They were

merely pretested on the first task, which was the word recognition test mentioned in the previous section.

Students were instructed individually. Each subject completed all three learning tasks in the order from task one to three in one session. Allocation of subjects to the instructional sessions was randomized across the four groups.

The initial instruction provided to the 90% mastery, 70% mastery and non-mastery groups included the teaching on all the 60 words for the word recognition task, all 30 words for the vocabulary task and all the 20 basic sentences for the word order task. Each child was presented one item at a time, then a response obtained and feedback provided. A correct response was followed by immediate verbal reinforcement. When the child gave an incorrect response, the correct answer was explained and in the case of the vocabulary task, additional pictorial illustrations were used to facilitate learning.

Apart from the initial instruction, subjects in the 90% and 70% mastery groups were provided additional learning trials on each of the three tasks until the prespecified mastery level was achieved. One set of instructional material (10 items) comprised a learning trial. For each learning trial, the same procedure as that described for the initial instruction was employed. Mastery of the task was defined as attainment of the prespecified performance level in two consecutive trials, a procedure recommended by Thorndike and Hagen (1977).

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Phase three - evaluation of immediate summative achievement. All subjects who participated in the instructional sessions during one day were administered the two immediate summative achievement tests together in a group at the end of the same day. Each group usually consisted of four to six children and included subjects from all treatment groups. The immediate cloze posttest was always administered first, then the immediate comprehension posttest.

Phase four - evaluation of long-term retention. The two long-term retention tests were administered to subjects two weeks after their individual instructional sessions. Subjects took the tests in groups of 12 to 15, with subjects from all four treatment groups included in each session. The long-term cloze retention test was administered first, then the long-term comprehension retention test.

RESULTS

For each subject four CEB measures were obtained before the treatment programme and four achievement measures taken after treatment. Descriptive statistics for these eight measures are reported in Table 1.

Immediate Achievement

To test the first research hypothesis of a significant overall CEB x treatment interaction on immediate summative achievement in reading comprehension, a stepwise multivariate multiple regression analysis was completed, a technique recommended by Cronbach & Snow (1977). The criterion variables

were the two posttest measures, the immediate cloze and the immediate comprehension scores. There were three sets of predictor variables. The first set of predictors consisted of the four CEB measures, word recognition test (X_1), word attack skills test (X_2), ACER Reading (X_3) and PMA (X_4). The second set of predictors was labelled Treatment and consisted of three variables (X_5, X_6, X_7) representing three orthogonal contrasts among the four groups. The first contrast (X_5) compared the two mastery groups (90% and 70%) with the two control groups (non-mastery and control). The second contrast (X_6) compared the 90% mastery group with the 70% mastery group, while the third (X_7) contrasted the non-mastery group with the control group. The third set of predictors consisted of 12 interaction terms (X_8 to X_{19}) which were carried by the cross products of each of the four CEB measures with each of the three contrast coding variables.

The multivariate F test of association between the predictor variables and criterion variables revealed a significant relationship ($F(38,318) = 9.78$, $p<.0001$). CEB, treatment and CEB x treatment interaction together determined, to a significant extent, the learning outcomes. The multiple Rs for the criterion variables immediate cloze and immediate comprehension were .83 and .79, respectively. Thus 69% of the variance in the immediate cloze measure and 63% of the variation in the immediate comprehension measure were jointly accounted for by the three sets of predictors.

Results of the stepwise regression tests of significance are presented in Table 2. The null hypothesis of no interaction was rejected ($F(24,318) = 1.75$, $p<.02$). Further, both univariate F tests on the two criterion variables, cloze and comprehension, attained significance at the .05 level ($F(12,160) = 2.00$, $p<.03$ and $F(12,160) = 1.86$, $p<.05$). The significant CEB X treatment interaction indicated that the treatment effect on both cloze and comprehension measures was conditional on the students' CEB levels.

Insert Table 2 about here

Comparison of Regression Slopes

A significant interaction can be interpreted to indicate significant differences in regression slopes among treatment groups. To facilitate illustration and conceptualization, the regression of the two summative achievement measures (immediate cloze and immediate comprehension) on the two specific CEB measures (word recognition and word attack skills) were examined separately. Thus four sets of four regression equations (Table 3) were compared, following the procedures outlined in Cohen and Cohen (1975, p.314-319). Within each set, three a priori contrasts were made. The first contrast examined the regression slopes of the two mastery groups (90% and 70%) relative to the two control groups (non-mastery and control). The second contrast compared the regression slope of

the 90% mastery group with that of the 70% mastery group. Finally, the regression slopes of the non-mastery and control groups were contrasted.

Insert Table 3 about here

A relatively consistent pattern of results emerged from the comparison of regression slopes. There were significant slope differences between the 90% and the 70% mastery groups in the regression of immediate comprehension scores on both word recognition ($F\ (1,173) = 7.66$, $p < .01$) and word attack skills ($F\ (1,173) = 4.02$, $p < .05$). On the other hand, slope comparisons of the regression of immediate cloze scores on the same two specific CEB measures revealed no significant differences among the four groups.

Regression of immediate comprehension scores on word recognition. As illustrated in Fig. 1, the slope of the regression line for the 90% mastery group was markedly less steep than that for the other three groups. This was reflected in the smaller regression coefficient for the 90% mastery group (.12) which indicated a weaker relation of the students' initial ability as measured by the word recognition test with learning outcome as measured by the immediate comprehension posttest. Further, the intercept for the 90% mastery group (49.82) was also substantially higher than the others. At high CEB levels (that is, where X is near 60), all four groups

showed high achievement on the immediate comprehension test, but at low CEB levels (that is, where X is near 0), only the 90% mastery group showed high achievement.

Insert Figure 1 & 2 about here

Regression of immediate comprehension scores on word attack skills. As illustrated in Fig. 2, the slope of the regression line for the 90% mastery group was less steep than that for the 70% mastery group. The intercept for the 90% mastery group (44.57) was also much higher than that for the 70% mastery group (27.21). At high word attack skills levels, both groups showed more or less the same high achievement on the immediate comprehension test; but at low word attack skills levels, the 90% group attained a higher achievement than the 70% group.

Long-term Retention

To test the second research hypothesis of a significant overall CEB x treatment interaction on long-term retention, another stepwise multivariate multiple regression analysis was completed. The criterion variables were the two long-term retention tests, the long-term cloze scores and the long-term comprehension scores. The same three sets of predictors employed in the analysis of the immediate posttest results were used in this analysis on the long-term retention results. These were, in order, the four CEB measures, the treatment contrasts and the set of CEB x treatment interactions.

The multivariate F test of association between the predictor variables and criterion variables revealed a significant relationship ($F(38,318) = 8.42$, $p<.0001$). CEB, treatment and CEB x treatment interaction together determined, to a significant extent, the learning outcomes. The multiple Rs for the criterion variables long-term cloze and long-term comprehension were .82 and .76, respectively. The three sets of predictors together accounted for 68% of the variation in the long-term cloze measure and 57% of the variation in the long-term comprehension measures.

Results of the stepwise regression tests of significance are reported in Table 4. The CEB x treatment interaction effect on variation in the long-term retention scores, eliminating the CEB and treatment main effects, marginally failed to reach significance ($F(24,318) = 1.44$, $p<.09$). The findings suggested that the CEB x treatment interaction effect for the long-term retention measures was attenuated. The null hypothesis of no significant interaction on the long-term retention measures had to be accepted.

Insert Table 4 about here

Finding the interaction nonsignificant, the stepwise analysis model allowed the effect of the preceding set of predictors to be validly tested (Bock, 1975). The treatment main effect, eliminating the CEB main effect, was examined

next. This stage of the analysis can in effect be interpreted in conventional analysis of covariance terms (Cohen and Cohen, 1975, p.345). In substance, the treatment main effect was tested for significance after partialling out the covariates, which in the present case comprised the four CEB measures.

As depicted in Table 3, there was a significant multivariate treatment main effect ($F(6,342) = 3.00$, $p<.01$). Further, both univariate F tests on the long-term cloze and the long-term comprehension variables attained significance ($F(3,172) = 4.36$, $p<.01$ and $F(3,172) = 3.60$, $p<.05$, respectively). These results indicated that there were significant group differences on both the long-term cloze and the long-term comprehension variables.

The three a priori orthogonal contrasts (as set up in the three contrast coding variables) were also examined separately. Multivariate results revealed that only the first contrast, the comparison of the two mastery with the two control groups, attained significance ($F(2,173) = 5.46$, $p<.01$). Univariate F tests for both the long-term cloze and long-term comprehension variables were significant ($F(1,174) = 7.50$, $p<.01$ and $F(1,174) = 7.30$, $p<.01$, respectively), indicating that the two mastery groups (90% and 70%) were significantly different from the two control groups (non-mastery and control) on both the long-term cloze and the long-term comprehension variables. Examination of group means (Table 1) revealed that the two mastery groups attained higher

mean scores than the two control groups on both long-term retention tests.

DISCUSSION

The findings of the present study confirmed the CEB x treatment interaction observed in the pilot investigation. There was a significant overall CEB x treatment interaction on immediate summative achievement in reading comprehension. Results indicated that the effects of the mastery learning programme on immediate achievement varied significantly with the initial level of ability of the subjects.

The significant interaction was not merely an artifact of a ceiling effect as the difficulty level of the outcome measures in the present study was extended beyond an average grade three level. Rasch's simple logistic model was employed in the construction of the assessment instruments, thus making it possible to transform the total test scores to a linear scale and to extend the difficulty range of the test items beyond a single grade level by means of test linking. The upper range of the comprehension tests was pitched at normal late grade four and beginning grade five levels. These procedures helped to eliminate the possibility of a ceiling effect and provided valid measures to study change and growth.

The comparison of regression slopes indicated that the mastery learning programme benefited the low CEB students relatively more than it did the high CEB students. It was found that at high CEB levels all four groups showed equally

high achievement on the comprehension tests, but at low CEB levels the 90% mastery learning group outperformed the other three groups. The 90% mastery learning programme was effective in enabling the low CEB mastery learning students to attain a high level of competence in reading comprehension, such that their performance was superior to those low CEB control students who were not provided with the mastery learning programme. On the other hand, the same mastery learning programme did not substantially benefit the high CEB mastery learning students. The high CEB control students demonstrated the same level of competence in reading comprehension in the absence of the mastery learning programme as the high CEB mastery learning students who received the mastery learning instruction.

The finding that low CEB students benefited relatively more than high CEB students from the mastery learning programme was consistent with the general findings observed in other mastery learning interaction studies reported in the literature. Wyckoff (1974) obtained a similar finding. In his study it was found that the low reading ability students in a mastery learning group attained higher scores than the low reading ability students in a control group on a summative test. However, the high reading ability students in both the experimental and control groups achieved comparable high scores on the same test. Similarly, the underprivileged group in the study by Detheux et al. (1974), the below average IQ group in

the investigation by Kim (1969), and the students with low pretest scores in the studies by Burrows and Okey (1975) and Tobias and Ingber (1976) were all particularly advantaged by mastery learning instruction relative to students with high pretreatment scores in the same mastery learning programme.

The significant interaction observed in the present project is consistent with Jensen's (1968) proposition on the trainability and educability of children from different social groups. Jensen framed the hypothesis that children of low cognitive ability should find special profit in a strong instructional model. In Jensen's view, these children should benefit from instructional approaches that utilize operant conditioning techniques, such as systematic monitoring of learning activities, active engagement of the learner, frequent practice, and immediate feedback and reinforcement. The above features can be found in Bloom's mastery learning strategy. In mastery learning procedures, the organization of content material into a sequence of learning units, the statement of objectives and mastery criterion, the frequent diagnostic assessment, and the opportunities for review and relearning all serve to produce a systematic, step-by-step and highly structured instructional model which proved to be especially beneficial to the low CEB students in the present project.

A possible explanation concerning the differential effectiveness of mastery of the three reading skills on reading comprehension for high and low CEB students can be found in

LaBerge and Samuels's automaticity theory (1974). Briefly, the theory postulates that reading involves a series of basic processes which may operate simultaneously in an integrated manner so long as the processing is automatic with no more than one process requiring attention at any one time. It has been suggested that when decoding skills are developed to the automatic level, the maximum amount of attention can be directed to obtaining meaning from the decoded material, resulting in a higher level of comprehension. It is likely that the high CEB students in the present research had developed automatic decoding skills and the mastery instruction on the three basic skills was redundant. The same instruction, on the other hand, could have benefited the low CEB group and freed their limited processing capacity for higher comprehension processes. These low CEB students were therefore more likely to achieve higher scores on the comprehension tests. These findings suggest the tentative conclusion that specific instruction on word knowledge skills to a high mastery level may not be necessary for high CEB pupils to achieve proficiency in reading comprehension. For low CEB pupils, however, such specific instruction may enable them to attain a high level of competence in reading comprehension. Fleisher, Jenkins & Pany (1979), Samuels (1979) and Weaver (1979) have also suggested that low ability students normally require more explicit and structured instruction in reading. The finding of the present research is consistent with such views. The direct

and explicit mastery learning instruction on the three reading skills was found to be particularly beneficial to the low CEB students.

Further, in the context of the present research, it seems likely that the mastery learning instruction on the three reading skills has provided a general remedial intervention. This concept of remediation corresponds to one of the approaches of matching aptitude and treatment suggested by Cronbach and Snow (1977). The low CEB students in the present research were so classified because of their relatively poor word recognition, word attack, vocabulary and comprehension skills (as assessed by the several CEB tests). In this context it is highly likely that mastery learning of the word recognition, word meaning and word order skills helped to compensate for their word knowledge deficiencies such that after the treatment programme these low CEB students did not have to rely on laborious word-by-word reading, which is typical of poor comprehenders (Golinkoff, 1976). It is also likely that mastery of the word recognition task enabled instantaneous decoding of the words in the comprehension passages such that their limited processing capacity was freed for higher comprehension processes. Further, mastery of the word meaning and word order tasks could have provided them with the ability to work with units larger than the single word and to make use of semantic and syntactic information. These are abilities observed among good comprehenders (Golinkoff, 1976).

The finding of a significant CEB x treatment effect confirms the hypothesized interaction deduced from Bloom's postulates of mastery learning. Bloom (1976) maintains that mastery learning enables all students to attain high levels of achievement with little variation in achievement measures among students. It was explained earlier that a reduced standard deviation of the achievement measures and a smaller correlation between the initial ability and achievement measures will result in a less steep regression slope. This was exactly what was observed in the present investigation. The standard deviations of the achievement measures for the 90% mastery group were smaller than those for the other treatment groups. The correlations between the CEB and achievement measures were also smaller for the 90% mastery group compared with those for the other treatment groups. As a consequence, the regression coefficients for the 90% mastery group were much reduced relative to those for the other groups. The findings of the present research project have strongly supported the view taken by the present investigators that Bloom is postulating an interaction when he states that mastery learning enables "four-fifths of students to reach a level of achievement which less than one-fifth attain under non-mastery conditions" (Bloom, 1976, p.5) and that "individual differences should approach a vanishing point" (p.16) following mastery learning instruction.

Bloom has described the phenomenon underlying a CEB x treatment interaction in his postulates of mastery learning but

he has not explicitly referred to it as an interaction nor has he formally stated the interaction term in his theory. The present finding suggests that this interaction term deserves to be formally stated in the theory.

Long-term Retention

The results of the present study indicated a nonsignificant overall CEB x treatment interaction on the long-term retention measures. The special facilitative effect of the mastery learning programme for the low CEB students observed in the immediate summative achievement data was not replicated when the students were tested after a duration of two weeks.

A closer examination of the long-term retention data revealed that the effect of the mastery learning programme was attenuated only among the low CEB students in the 90% mastery group. For all four treatment groups the means of the long-term retention measures were not much different from the means of the immediate achievement measures. A comparison of the regression equations for the four groups on both occasions (immediate and long-term) showed that it was the low CEB 90% mastery subgroup which deteriorated in performance on the long-term retention tests, but not the high CEB 90% mastery subgroup. It follows that the special facilitative effect of the mastery learning programme for the low CEB students observed in the immediate achievement data was not upheld in the long-term retention data, in spite of the fact that the low

CEB mastery learning students still outperformed the low CEB control students on long-term retention.

It seems likely that without the opportunity for review and overlearning, the performance of the low CEB mastery learning students on the long-term tests deteriorated relative to their performance on the immediate achievement tests. It is also possible that after the two-week interval during which no special treatment was provided, the comprehension competence of the low CEB mastery learning students was no longer aided by the mastery learning instruction on the three reading skills provided earlier. The findings suggest that a continuous programme of corrective instruction and review may be necessary before the special advantage of the mastery learning programme for low CEB students can be retained in the long term.

The present findings concerned with long-term retention indicated that regardless of CEB, all mastery learning students benefited from the programme. The treatment effect on the long-term measures, holding initial ability constant, was significant. Results of the *a priori* contrasts revealed that the two mastery groups were significantly superior to the two control groups in the long-term retention measures. Overall, the mastery learning instruction was effective, resulting in the mastery learning students attaining higher scores than the control students on the reading comprehension tests administered two weeks after instruction.

Implications

The special value of the mastery learning programme for low CEB students demonstrated in the present research has implications for instructional policy. The findings of the present study suggest that high CEB students may not require mastery learning instruction for much of their basic skills learning. Mastery learning makes great demands on the time and effort of both teachers and students, particularly in the early phases of such programmes. Students need extra time and effort with review or relearning if they are to meet the mastery requirements. Teachers have to spend a great deal of time and effort in preparing performance objectives and materials for formative assessment and corrective instruction and in following the mastery learning procedures in classroom teaching. If high CEB students do not seem to obtain any special benefit from mastery learning instruction, it may not be necessary to insist on mastery performance in every step of a learning sequence when teaching high CEB students. Rather, the resources may well be reserved for low CEB students who are more likely to be especially advantaged by this highly structured instructional system.

The findings of the present research generally support the value of explicit and systematic investigations of the interaction between CEB and instructional methods in mastery learning studies. Past research on mastery learning tended to ignore the interactive relationship between the CEB and

treatment variables. Too often these studies were interested only in the treatment main effect and employed only a single factor in their design. In so doing, the influence of CEB on the effectiveness of treatment was neglected. But in comparing the effects of mastery learning with those of conventional teaching approaches, Bloom is postulating a special facilitative effect of the mastery learning procedures for low CEB students. The presence of this postulated CEB x treatment interaction is supported by the data from the present study. It is recommended that future research on mastery learning should routinely test the significance of CEB x treatment interactions. Only in the absence of a significant interaction is it logical to examine the overall average effect of mastery learning instruction.

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Table 1

Means and Standard Deviations of CEB and Achievement Measures for the Four Treatment Groups

	90% mastery		70% mastery		Non-mastery		Control	
	X	SD	X	SD	X	SD	X	SD
Age (in months)	96.51	4.07	97.76	4.48	96.58	3.96	96.89	4.65
No. of boys	25		24		23		22	
No. of girls	20		21		22		23	
CEB measures								
Word recognition	42.96	10.17	41.31	12.10	40.98	12.27	40.53	13.67
Word attack skills	109.29	10.57	106.31	12.34	105.58	10.47	105.42	14.28
ACER Reading	28.49	11.14	28.40	12.80	29.71	11.94	29.11	12.19
PMA	85.40	11.57	84.18	13.88	84.33	14.91	81.60	13.16
Achievement measures								
Immediate cloze	59.51	4.18	56.44	5.11	54.96	5.75	52.71	6.36
Immediate comprehension	54.91	3.55	51.51	4.94	51.96	4.85	50.93	4.35
Long-term cloze	57.76	4.83	55.33	6.21	54.89	5.21	54.27	7.23
Long-term comprehension	54.51	5.37	52.76	6.08	52.29	6.77	50.96	6.05

Table 2

Summary of Results for Stepwise Regression Tests of Significance on Immediate Summative Achievement

Source of variation	d.f.	SSCP: Immediate cloze (Y_1)	SSCP: Immediate comp. (Y_2)	Multivariate F (d.f.)	Univariate F	% increase in R^2
CEB	4	3168		24.18**	Y_1 44.95**	Y_1 50.68
		2465	1931	(8,348)	Y_2 42.50**	Y_2 49.28
Treatment, eliminating CEB	3	886		13.20**	23.13**	14.18
		475	328	(6,342)	11.31**	8.36
CEB x treatment, eliminating treatment and CEB	12	286		1.75*	2.00*	4.58
		132	203	(24,318)	1.86*	5.19
Residual	160	1911				
		432	1457			
Total	179	6251				69.44
		3504	3919			62.83

** significance at $p<.01$

* significance at $p<.05$

Table 3

Regression Equations for the Four Treatment Groups

Treatment group	Regression of immediate comprehension on	
	word recognition	word attack skills
90% mastery	$Y_1 = .12X_1 + 49.82$	$Y_1 = .09X_2 + 44.57$
70% mastery	$Y_1 = .29X_1 + 39.36$	$Y_1 = .23X_2 + 27.21$
Non-mastery	$Y_1 = .28X_1 + 40.40$	$Y_1 = .34X_2 + 16.03$
Control	$Y_1 = .25X_1 + 40.96$	$Y_1 = .21X_2 + 28.67$
	Regression of immediate cloze on	
	word recognition	word attack skills
90% mastery	$Y_1 = .17X_1 + 52.12$	$Y_1 = .19X_2 + 39.03$
70% mastery	$Y_1 = .32X_1 + 43.27$	$Y_1 = .27X_2 + 27.42$
Non-mastery	$Y_1 = .36X_1 + 40.32$	$Y_1 = .35X_2 + 18.04$
Control	$Y_1 = .33X_1 + 39.34$	$Y_1 = .30X_2 + 20.98$

Y_1 = predicted immediate comprehension scores

Y_2 = predicted immediate cloze scores

X_1 = word recognition scores

X_2 = word attack skills scores

Table 4

Summary of Results for Stepwise Regression Tests of Significance on Long-Term Retention

Source of variation	d.f.	SSCP: Immediate cloze (Y_3)	SSCP: Immediate comp. (Y_4)	Multivariate F (d.f.)	Univariate F	% increase in R^2
CEB	4	3949 3727	3561	31.28** (8,348)	Y_3 66.83** Y_4 47.89**	Y_3 60.43 Y_4 52.26
Treatment, eliminating CEB	3	183 176	192	3.00** (6,342)	4.36** 3.60*	2.80 2.82
CEB x treatment, eliminating treatment and CEB	12	284 -12	153	1.44 (24,318)	1.79 .70	4.35 2.24
Residual	160	2118 920	2908			
Total	179	6534 4811	6814			67.58 57.32

** significance at $p<.01$

* significance at $p<.05$

Figure Captions

Figure 1. Regression of the immediate comprehension scores on the word recognition test scores for the 90% mastery, 70% mastery, nonmastery and control groups.

Figure 2. Regression of the immediate comprehension scores on the work attack skills test scores for the 90% mastery, 70% mastery, nonmastery and control groups.

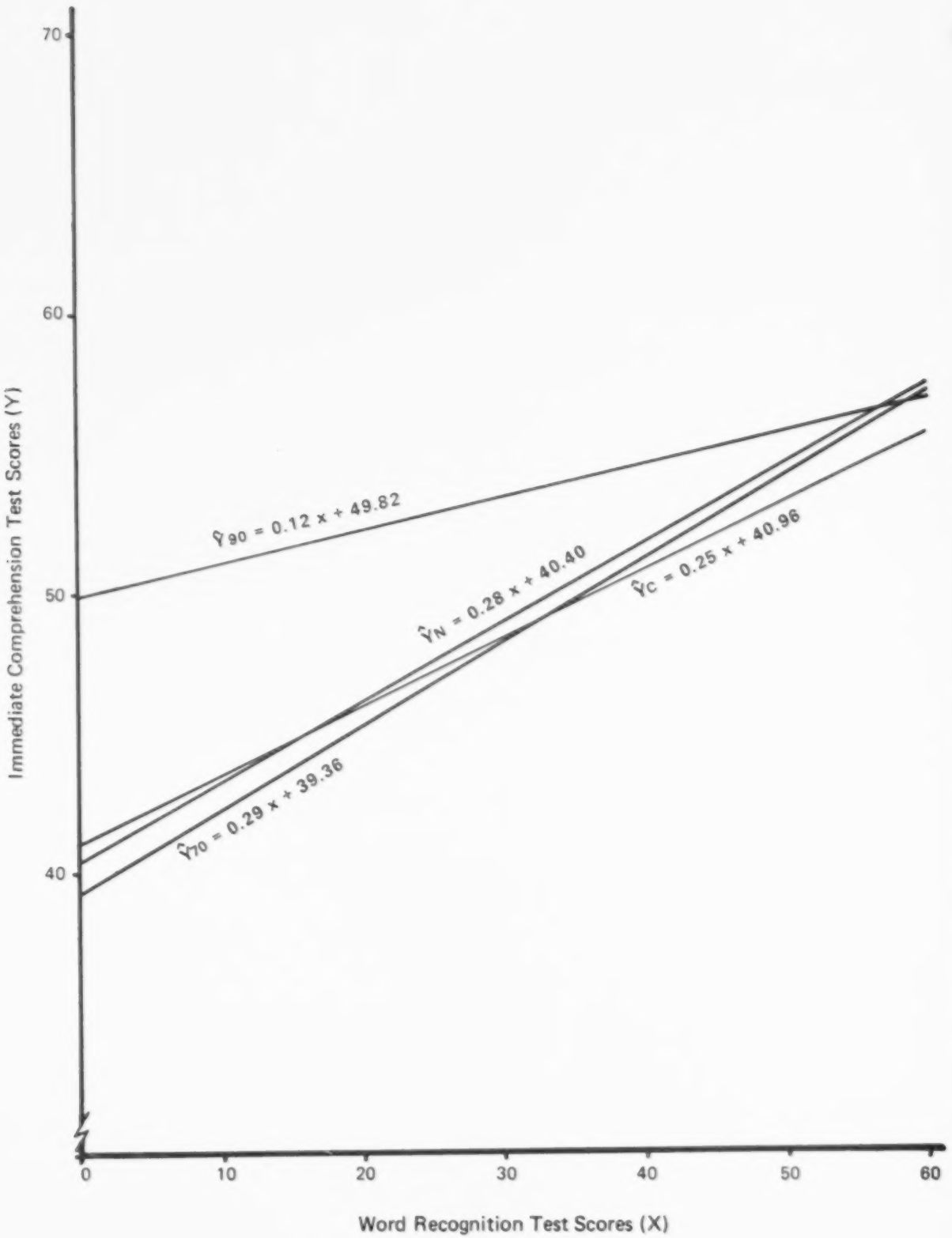

Figure 6.1 Regression of the immediate comprehension scores on the word recognition test scores for the 90% mastery, 70% mastery, nonmastery and control groups.

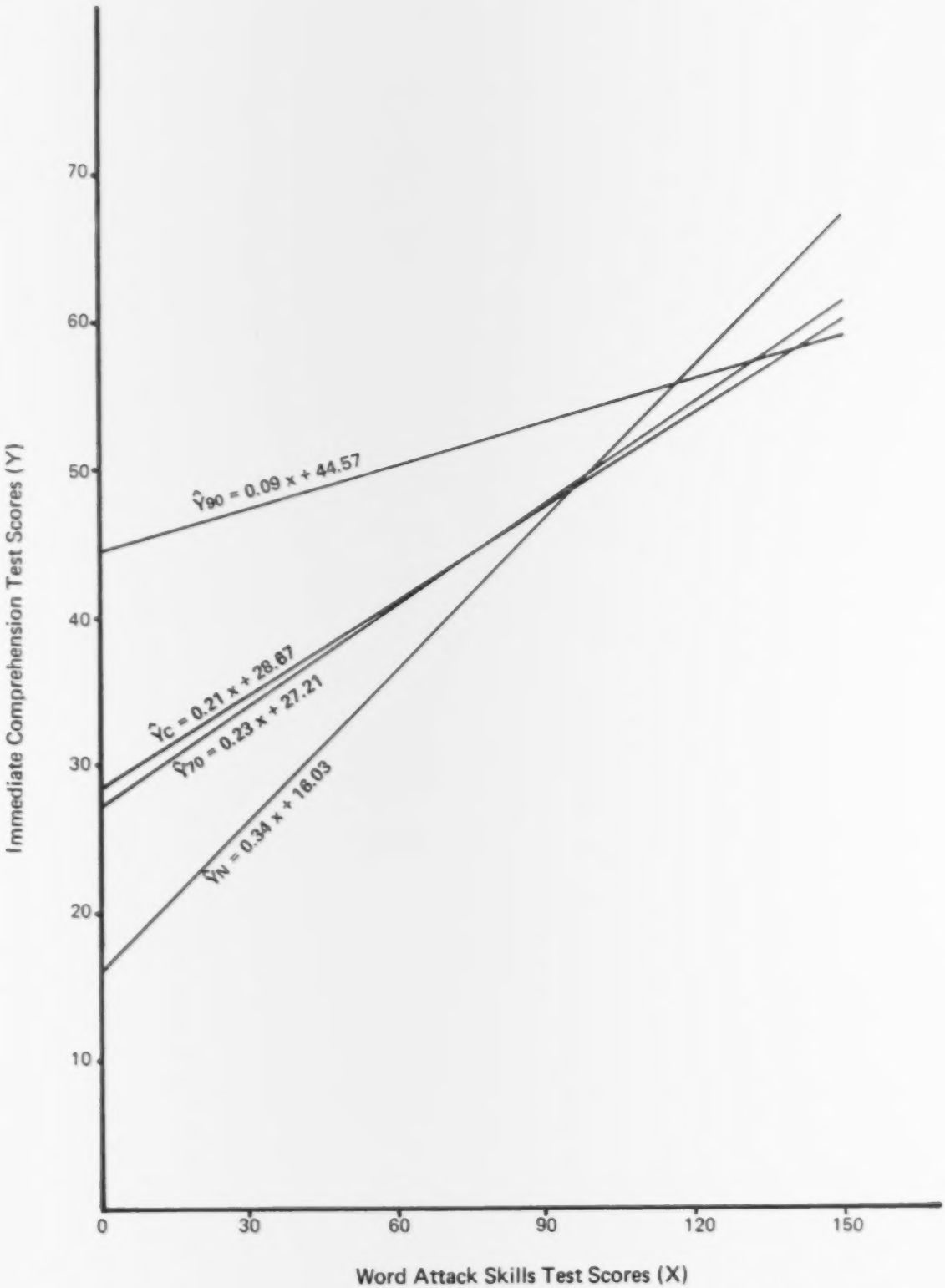

Figure 6.2 Regression of the immediate comprehension scores on the word attack skills test scores for the 90% mastery, 70% mastery, nonmastery and control groups.